PRESENTATION OF THE FRENCH GUIDE TO THE APPLICATION OF EUROPEAN STANDARDS FOR BITUMINOUS MIXTURES AND SURFACE DRESSINGS FOR AIRPORT PAVEMENTS

By:
Bernard Depaux & Patrick Lerat
French civil Aviation technical center (DGAC/STAC)
31, avenue du Maréchal Leclerc 94 381 Bonneuil sur Marne
France
Jean-Paul Michaut
Union des Syndicats de l'Industrie Routière Française (USIRF)
7, place René Clair 92653 Boulogne-Billancourt Cedex
France
bernard.depaux@aviation-civile.gouv.fr
patrick.lerat@aviation-civile.gouv.fr
michaut@siege.colas.fr

PRESENTED FOR THE
2010 FAA WORLDWIDE AIRPORT TECHNOLOGY TRANSFER CONFERENCE
Atlantic City, New Jersey, USA

April 2010

INTRODUCTION

Given the specific nature of airport pavements, and the appearance of new product standards derived from European standards, this study helps project managers to make the right product choices for their airport pavement construction and rehabilitation projects.

The first part of this communication provides a reminder of airport terminology and definitions.

The second part indicates the procedure to be followed when choosing products and defining the performance requirements of mixtures (formulation) and the characteristics of their components, in order to provide the best possible response to the project requirements.

The third part provides recommendations for characteristics to be achieved, both in laboratory testing (mix design sample for type testing, and formulation levels) and on site, from production of the mixture to its application. The annexes consist of various summary tables intended to facilitate the designer's task.

ROLE OF THE DIFFERENT LAYERS OF A PAVEMENT

In general, a pavement consists, from top to bottom, of various courses of materials designed to enable it to resist traffic-induced stresses and to distribute these to the pavement base or foundation.

Surfacing must be resistant to flow and punching phenomena, and withstand the ageing caused by atmospheric agents, thermal gradients and hydrocarbon attack : the surface course, in actual contact with tyres, must be capable of providing the adherence characteristics prescribed by air transport specifications. The binder course is an intermediate layer between the wearing course and the road base or old pavement. In airport pavements, a binder course is not systematically used. Its principal application is in maintenance works, to improve evenness or to delay the spread of cracks from the deeper layers to the wearing course.

The foundation and base course utilize appropriate materials to provide sufficient mechanical resistance to bear the vertical loads imposed by traffic, and to spread them over the ground or subgrade.

The capping layer renders the subgrade more homogeneous, and improves its bearing capacity characteristics.

Tack coats play an important part in ensuring long pavement life. Their functions are as follows:

- mechanical adhesion between the different courses of the pavement structure; the quality of this adhesion strongly influences the rigidity of the pavement. The design calculation should assume that all courses must be tack coated, and that any defect in the tack coating will in the long term result in structural deterioration.
- resistance to shearing; where severe tangential stresses exist, defects in the tack coating can have short-term consequences such as horizontal flow, causing ridging and/or cracking in the surface course
- waterproofing; the contribution of tack coating to waterproofing is particularly important with aggregates of small size.

CAUSES OF DETERIORATION IN AIRPORT PAVEMENTS

Deterioration occurs in airport pavements through the effects of aircraft traffic and climatic factors

- Traffic effects causing mechanical stresses

- shearing, which results from horizontal stresses caused by tangential efforts transmitted by tyres when aircraft make turns
- rutting, the permanent strain due to frequent passages of loads at low speeds
- punching, due to permanent strains caused by static loads.

- Climatic effects

- ageing which only affects the surface course, and which depends on the climate, the nature of any products applied to it, and any pollution. The ability of a pavement to resist ageing is called its durability.

Other aggressive effects include chemicals (e.g. accidental spillage of oils or hydrocarbons). Although these can have a very aggressive effect on the life expectancy of a pavement, they are not a sufficiently discriminating factor to be considered as a criterion when assessing the levels of aggression presented in table 1 below.

However, this factor will be taken into account when determining the choice of bituminous mixture to be implemented, and defining its mechanical properties.

Table 1.
Assessment of aggression levels and surface quality characteristics of a pavement

		Shearing	Rutting	Punching	Durability	Friction
Parking areas		++	+++	+++	++	++
Runways	Main part	+	+	+	++	+++
	Turning area	+++	++	+	+++	++
	Exit	+++	+	+	++	+++
	Threshold [(a)]	+++	+	++	+++	+++
Taxiways	Main part	+	++	+	++	++
	Intersections	++	++	++	+++	++
Apron or holding area		+	+++	+++	++	++

(a) including touch-down area
+ : Low level ++ : Medium level +++: High level

CHOOSING THE RIGHT PRODUCTS - RECOMMENDATIONS

Table 2 below recapitulates the products available in France for use in building and renovating airport pavements. This table gives for each product its classification, grading and dimensions in use, and prescribes maximum acceptable strains for existing pavements before application of a new course of a bituminous mixture.

- Terminology

EB10-BBA C: airport bituminous concrete, grading 0/10 continuous

EB14-BBA C: airport bituminous concrete, grading 0/14 continuous

EB10-BBA D: airport bituminous concrete, grading 0/10 discontinuous

EB10-BBA D: airport bituminous concrete, grading 0/14 discontinuous

EB10-BBME: high-modulus bituminous concrete, grading 0/10

EB14-BBME: high-modulus bituminous concrete, grading 0/14
EB10-BBM: thin bituminous concrete, grading 0/10
EB14-BBM: thin bituminous concrete, grading 0/14
BBTM 6: very thin bituminous concrete, grading 0/6.3
BBTM 10: very thin bituminous concrete, grading 0/10
EB10-BBSG: semi-granular bituminous concrete, grading 0/10
EB14-BBSG: semi-granular bituminous concrete, grading 0/14
EB14-GB: bitumen-bound graded aggregate, grading 0/14
EB20-GB: bitumen-bound graded aggregate, grading 0/20
EB10-EME: high-modulus bituminous mixture, grading 0/10
EB14-EME: high-modulus bituminous mixture, grading 0/14
EB20-EME: high-modulus bituminous mixture, grading 0/20
EP: Grouted previous bituminous mixtures
EB4 or EB6: bitumen-bound sand, grading 0/4 or 0/6
ECF: slurry surfacing
ESU: surface dressing.

Table 2
Products which may be used for airport pavements

Products					Average thickness in use ------------- and minimum thickness at any point	Maximum acceptable lack of flatness of existing substrate
Name		Classification Class or type	NF EN reference	Grading [(1)]		
EB10-BBAC	Surface course and binder course	Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/10	6 to 7 cm 4 cm	≤ 2 cm
EB10-BBA D	Surface course	Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/10	4 to 5 cm 3 cm	≤ 2 cm
EB14-BBA C	Wearing surface and binder course	Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/14	7 to 9 cm 5 cm	≤ 2 cm
EB14-BBA D	Surface course	Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/14	5 to 7 cm 4 cm	≤ 2 cm
EB10-BBME	Surface course and binder course	Class 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/10	5 to 7 cm 4 cm	≤ 2 cm
EB14-BBME	Surface course and binder course	Class 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/14	6 to 9 cm 5 cm	≤ 2 cm
EB10-BBM	Surface course and binder course	Type A, B or C according to grading curve. Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/10	3 to 4 cm 2.5 cm	≤ 1,5 cm

EB14-BBM	Surface course and binder course	Type A, B or C according to grading curve. Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/14	3.5 to 5 cm / 3 cm	≤ 1,5 cm
BBTM 6	Surface course	Class 1 or 2	NF EN 13 108-2	0/6.3	2 to 3 cm / 1.5 cm	≤ 1 cm
BBTM 10	Surface course	Class 1 or 2	NF EN 13 108-2	0/10	2 to 3 cm / 1.5 cm	≤ 1 cm
EB10-BBSG	Surface course and binder course	Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/10	5 to 7 cm / 4 cm	≤ 2 cm
EB14-BBSG	Surface course and binder course	Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/14	6 to 9 cm / 5 cm	≤ 2 cm
ECF	-	-	in progress	0/6 to 0/10	Dosage 10 or 15 kg/m²	≤ 1 cm
EB14-GB	Base	Class 2, 3 or 4 according to mechanical performance	NF EN 13 108-1	0/14	8 to 14 cm / 6 cm	≤ 2 cm
EB20-GB	Base	Class 2, 3 or 4 according to mechanical performance	NF EN 13 108-1	0/20	10 to 16 cm / 8 cm	≤ 3 cm
EB10-EME	Base	Class 1 or 2 according to mechanical performance	NF EN 13 108-1	0/10	6 to 8 cm / 5 cm	≤ 2 cm
EB14-EME	Base	Class 1 or 2 according to mechanical performance	NF EN 13 108-1	0/14	7 to 13 cm / 6 cm	≤ 2 cm
EB20-EME	Base	Class 1 or 2 according to mechanical performance	NF EN 13 108-1	0/20	9 to 15 cm / 8 cm	≤ 2 cm
ESU	-	Class A, B or C	NF EN 12 271	2/4	-	≤ 2 cm
EB4 or EB6 - bitumen-bound sand (2)	-	-	NF EN 13 108-1	0/4 or 0/6	2 cm	≤ 1 cm
Grouted pervious bituminous mixtures (EP)	-	-	None	-	4 to 5 cm	≤ 2 cm

(1) A grading corresponding to sieve D of series 1 is admissible.
(2) This is generally prescribed to limit or retard the occurrence of cracks, particularly in the case of foundations treated with cementitious binders.

Many other products are available on the market. However, given the poor fit between their characteristics and airport pavement applications, their use in airport surface courses is strongly discouraged, and in many cases forbidden:

- *Nailed bituminous concrete* - (risk of stripping, and of scattering nails).
- *Porous bituminous concrete* - (risk of over-rapid silting up in low-traffic areas and of stripping due to shearing effect).
- *Ultra- thin bituminous concrete* – (risk of stripping due to shearing effect).

- *Flexible bituminous concrete* – (use must take account of its particular characteristics: fairly low geometric roughness, strong sensitivity to permanent deformation).
- *Airport bituminous concrete 0/10 C* – (not to be used for surface courses of runways because of the difficulty of achieving sufficient geometric roughness).

- Decisions on which product to use – Determining stress levels

Specifications relating to the choice of products are guided by a concept which we shall call the "stress level". For a given airport this results from the combination of two factors: class of traffic and type of climate.

The method used to define the traffic class is to establish a realistic order of magnitude for the various stresses applied on the courses of a pavement by the passage of an aircraft. Several criteria are liable to influence determination of the traffic class: the weight of the aircraft, number of landing wheels and their tyre pressures, area of tyre/runway contact, tyre pressures, etc. We introduce the idea of an "aircraft group" based on two variables to represent the impact of an aircraft on a pavement: tyre pressure (P) and the number of wheels (R) of the main landing gear assembly. Table 3 presents five aircraft groups based on the product of P x R. A traffic class is determined for the aircraft representing the greatest constraint using any part of the airport. Thus, different traffic classes can be defined for different parts of the airport (runways, taxiways, parking areas, etc.) and for homogeneous stresses (same aircraft type and frequency).

Table 3
Determining the traffic class

Tyre pressure x no. of wheels (Mpa) / Frequency (F)*	Light aircraft - total aircraft weight < 5 700 kg	P x R <2	2≤ P x R< 4.1	4,1 ≤ P x R< 5.5	5.5 ≤ P x R
	Group 1	Group 2	Group 3	Group 4	Group 5
F < 10 mvts/day**	CT1	CT2	CT2	CT3	CT4
10 mvts/d ≤ F ≤ 100 mvts/d	CT1	CT2	CT3	CT4	CT5
F > 100 mvts/day	CT1	CT2	CT4	CT5	CT5

* One movement corresponds to a takeoff or landing
** if F > 1 movement per day, the traffic class so determined is adopted for all areas of the airport
If F ≤ 1 movement per day, the traffic class so determined is only recognized for that particular part of the airport.

The traffic class is determined by reference to the other aircraft using the airport.

Type of climate :
Four types of climate (table 4) have been defined for France, on the basis of temperature readings taken over a period of several years (Météo France, the national meteorological office, has calculated so-called "standard values" from daily maximum temperature readings taken in the two hottest months and the two coldest months of the year).

Table 4
Definition of types of climate

		Average of daily maximum temperatures in the hottest two months of the year	
		T° ≤ 27°C	T° > 27°C
Average of daily minimum temperatures in the coldest two months of the year	T° > 14°C	Type 4: predominantly tropical	
	0°C ≤ T° ≤ 14°C	Type 1: predominantly oceanic	Type 2: predominantly Mediterranean
	T° < 0°C	Type 3: predominantly continental or mountainous	Not relevant

Stress levels
Stress levels are determined with the aid of table 5, on the basis of the traffic class and type of climate.

Table 5
Determination of stress levels

Climate \ Traffic class	CT1	CT2	CT3	CT4	CT5
Oceanic	NS1	NS1	NS2	NS3	NS4
Continental					
Mediterranean		NS2	NS3	NS4	
Tropical					

- Determining product choices as a function of stress levels: surface course

To enable road builders to respond as fully as possible to the objectives and regulatory requirements in terms of resistance and surface condition, in normal operating conditions, table 6 lists products which can be used for surface courses according to certain stress levels.

All products shown can be used without any one having any kind of priority over the others. However, for new construction projects, use of BBA is favoured. Products of a superior performance class can always be preferred, provided that the economic assessment remains satisfactory. Similarly, in practice, to satisfy the general economic constraints of the project, it is possible to specify the use of one and the same product on all areas

- Resistance to aviation fuel

Parking areas built as lightweight pavement structures need special protection against attack by aviation fuel, often known as anti-kerosene protection. This protection is achieved either on the surface or in the material itself. On the surface, a filler is spread over the surface to be treated after the bituminous mixture has been applied, in order to prevent the petroleum products from seeping into the ground. Application of this product must be carried out in accordance with the manufacturer's instructions. In the material itself: in this case, the bituminous mixture must be aviation-fuel-resistant. A special binder is generally used; this binder endues the mixture with a particular resistance to hydrocarbons (aviation fuel, lubricating and other oils) and good rutting resistance.

Table 6
Products that can be used for surface courses

Area of airport		NS 1	NS 2	NS 3	NS 4
Parking areas		EB-BBA 2, ESU, ECF, EP, EB-BBM 1	EB-BBA 3, EB-BBM 2 EB-BBME 1, EP	(***) EP (1)	(***) EP (1)
Runways(*)	Main part	EB-BBA 1, EB-BBM A1, EB-BBM B1 BBTM	EB-BBA 1, EB-BBM A2, BBTM	EB-BBA 2	EB-BBA 2
	Turning area		EB-BBA 2, EB-BBME 1	EB-BBME 2 (2)	EB-BBME 3 (2)
	Exit		EB-BBA 2, EB-BBM A2	EB-BBA 3 EB-BBME 2	EB-BBA 3
	Threshold (**)		EB-BBA 2, EB-BBM A2	EB-BBA 3 (2)	EB-BBA 3 (2)
Taxiways	Main part	EB-BBA 1, ECF, EB-BBM B2, BBTM	EB-BBA 2, EB-BBM B3, BBTM	EB-BBA 2, EB-BBME 1	EB-BBA 3, EB-BBME 2
	Intersections		EB-BBA 2, EB-BBM B3	EB-BBA 3, EB-BBME 2	EB-BBA 3, EB-BBME 2
Apron or holding area		EB-BBA1, ECF, EB-BBM B2, BBTM	EB-BBA 3, EB-BBM B3	EB-BBME 3	EB-BBME 3

(*) Use of EB10-BBA C is not recommended (inadequate geometric roughness)

(**) On military airfields, where fighter planes can cause deterioration of pavements constructed with bituminous mixtures (surface burning, oil spills, etc.) concrete pavements are recommended

(***) On traffic areas with a high risk of punching, cement concrete pavements are highly recommended.

(1) Use of this material is related to the pavement base which must possess a high stiffness modulus (for example, a semi-rigid or bituminous structure). In general, the pavement base consists either of graded aggregate bound with cementitious binders, or of a high-modulus bituminous mixture, or bitumen-bound graded aggregate.

(2) For better resistance to shearing strains, use of a modified binder is recommended.

- Determining product choices as a function of stress levels: binder courses and reshaping operations

The nature and performance classes of usable products are shown in table 7 below.

- Determining product choices as a function of stress levels: pavement base or foundation

The nature and performance classes of products which may be used for pavement bases are shown in Table 8 below.

Table 7
Products which can be used for binder or levelling (regulating) course

Area of airport		NS 1	NS 2	NS 3	**NS 4**
Parking areas		EB-BBM 1 EB-BBSG 1	EB-BBM 3 EB-BBSG 1	([1])	([1])
Runways	Main part	EB-BBM 1 EB-BBSG 1	EB-BBM 1 EB-BBSG 1	EB-BBM 2 EB-BBSG 1 EB-BBME 1	EB-BBSG1 EB-BBME1
	Turning area		EB-BBM 2 EB-BBSG 1	EB-BBM 3 EB-BBSG 1 EB-BBME 1	EB-BBSG 2 EB-BBME 2
	Exit				EB-BBSG 2 EB-BBME 2
	Threshold (*)				
Taxiways	Main part	EB-BBM 1 EB-BBSG 1	EB-BBM 2 EB-BBSG 1	EB-BBM 2 EB-BBSG 1 EB-BBME 1	EB-BBSG 1 EB-BBME 1
	Intersections			EB-BBM 3 EB-BBSG 1 EB-BBME 1	
Apron or holding area		EB-BBM 1 EB-BBSG 1	EB-BBM 2 EB-BBSG 1	EB-BBM 3 EB-BBSG 1 EB-BBME 1	EB-BBSG 2 EB-BBME 2

([1]) Not relevant. For parking areas where there is a high risk of punching occurring, cement concrete pavements are strongly recommended.

(*) On military airfields, where fighter planes can cause deterioration of pavements constructed with bituminous mixtures (surface burning, oil spills, etc.) concrete pavements are recommended

.

Table 8

Products which may be used for pavement bases

Airport area		NS1	NS2	NS3	NS4
Parking areas		EB-GB 2	EB-GB 2	([1])	([1])
Runways	Main part	EB-GB 2	EB-GB 2	EB-GB 2 EB-EME 1	EB-GB 3 EB-EME 2
	Turning area			EB-GB 3 EB-EME 1	
	Exit				
	Threshold (*)				
Taxiways	Main part Intersections	EB-GB 2	EB-GB 2	EB-GB 3 EB-EME 1	EB-GB 3 EB-EME 2
Apron or holding areas		EB-GB 2	EB-GB 2	EB-GB 3 EB-EME 1	EB-GB 3 EB-EME 2

([1]) Not relevant. For parking areas where there is a high risk of punching occurring, cement concrete pavements are strongly recommended

(*) On military airfields, where fighter planes can cause deterioration of pavements constructed with bituminous mixtures (surface burning, oil spills, etc.) concrete pavements are recommended

ON-SITE CHARACTERISTICS– VERIFICATION

The project manager's monitoring and progress-chasing role in on-site operations includes constantly verifying that the work is being carried out according to the requirements of the project owner. This applies to each phase of the works, and particularly to the need to verify that the characteristics prescribed in the technical clauses of the contract are indeed being observed. Specially, the nature of airport operations imposes strict requirements on pavement characteristics in terms of skid resistance and longitudinal evenness. The width and minimal slope of airport pavements imply very strict altimetric constraints to respect the correct values for slopes and the depth of depressions in particular. It should be noted that good skid resistance in rainy conditions can only be achieved by associating the properties of the surfacing with good surface geometry.

Lastly, the width of airport pavements requires a large number of joints, which are notoriously weak points of these pavements. Their execution must therefore be carefully verified.

- Geometry

To satisfy these requirements, several frames of reference are in force: ICAO Annex 14 [1], the French ministerial decree on airport approvals and operating procedures of 25 August 2003, Annex 1 of the French ministerial decree on the technical characteristics of certain land-based airports used by fixed-wing aircraft dated 10 July 2006 [2].

- Verification of evenness

The evenness of the surface course is verified according to standard NF P 98 218-3 and LPC method no. 46 [3]. Ratings are evaluated according to the specifications defined in the information note published by the LCPC and STAC.

The evaluation of the quality of evenness is based on measuring the longitudinal profile of a pavement using an LPC measuring device called a longitudinal profile analyser (APL [4]) and quantifying the data within a rating system classified by wavelength on a scale from 0 (very poor) to10 (excellent).

Determining the ratings requires prior digital analysis of the signals, filtered according to three wavebands defined as follows:

- Short wav:	from 0.707 m to 2.828 m
- Medium waves:	from 2.828 m to 11.312 m
- Long waves:	from11.312 m to 45.248 m

This method is applicable to all airport pavements, whatever their structure, regardless of whether they are situated on a civil or military airport, and in the context both of taking delivery of new pavements and of reinforcement or maintenance works.

The test method differentiates between evenness measurements taken on runways and those taken on taxiways. In the case of pavements of less than 1000 metres (for example, high-speed taxiways) it is more important to respect the medium-wave and long-wave requirements.

The attention of contractors and airport operators is drawn to the fact that civil engineering structures may make it difficult locally to attain the stated requirements. In such cases, the sections involved should be excluded from the study, and a specific study carried out on those sections. It is also important to bear in mind that:

- in the case of the construction of new pavements, the quality of evenness is strongly affected by the evenness quality of the underlying layers (binder course and base).

- in the case of pavement refurbishments (reinforcement or restoration of the surface course) with a single course treatment of 5 cm to 7 cm thickness, it is difficult to bring about significant improvement in evenness in long-wave areas.

The technical solutions offered here must be carefully defined, taking due account of the initial condition of the pavement. Consequently, the designer will wish to adopt the principle that, prior to any renovation work on the surface course, evenness should be measured before the work begins. This precaution makes it possible to verify the prior state of the pavement, and to avoid dispute after the work is completed, in the event of non-compliant measurements.

When evaluating the longitudinal evenness of a new pavement, the specifications shown in table 9 below should be applied.

Table 9

Specifications for rating the longitudinal evenness of an airport pavement

	Wavebands	New pavements L < 2 000 m	New pavements L ≥ 2 000 m	Pavements after maintenance works on several courses	Pavements after maintenance works on a single course
Overall requirements for all ratings of all profiles	Short	100 % ≥ 4 95 % ≥ 6 80 % ≥ 7		100 % ≥ 4 95 % ≥ 6 80 % ≥ 7	100 % ≥ 4 Existing maintained *
	Medium	100 % ≥ 5 80 % ≥ 8		100 % ≥ 5 80 % ≥ 8	Existing maintained *
	Long	100 % ≥ 7 80 % = 10	100 % ≥ 7 90 % = 10	Existing maintained *	Existing maintained *
Requirements by profile for the 3 central pairs of profiles	Short	100 % ≥ 6 90 % ≥ 7		100 % ≥ 6 90 % ≥ 7	Existing maintained *
	Medium	100 % ≥ 6 90 % ≥ 8		100 % ≥ 6 90 % ≥ 8	Existing maintained *
	Long	100 % ≥ 8 80 % = 10	100 % ≥ 8 90 % = 10	Existing maintained *	Existing maintained *

* Existing maintained = "average rating after works ≥ average rating before works and minimum rating after works ≥ minimum rating before works"

<u>REMARKS:</u>

(a) This table applies to the length measured, not the length of the pavement. It should be noted that when taking measurements at a speed of 72 km/h, a non-measured length of 2 x 200 m is necessary before and after the test area, for the approach before and for braking after the test, and to stabilize the digital filters.

*(b) The term "overall requirements" refers to the method of verifying these specifications. The overall analysis consists in verifying whether or not the ratings specified for all traces (14 or 18, as described in Module 4 of LPC test method no. 46) are attained.**

(c) The term "requirements by profile" also refers to the method of verifying these specifications. The overall analysis consists in verifying whether or not the specifications for each of the three central traces considered individually (centre line and +/- 2.50 m, as described in Module 4 of LPC test method no. 46) are attained. These requirements correspond to particular needs related to the passage of the forward landing gear of the aircraft (nose wheel) situated under the cockpit.

(d) *When 80%., 90% and 95% of the ratings calculated do not result in whole numbers, the score is rounded down if the difference is ½ point or less, or rounded up if above ½ point.*

(e) *These specifications are generally applicable in all cases of renovation of a surface course. However, in cases of maintenance work necessitating only one course, and when localized defects are detected during the taking of evenness measurements before maintenance works begin (short-wave ratings equal to or less than 2), it is necessary to undertake preparatory works such as reshaping or planning to enable these specifications to be applied.*

- Verification of skid resistance

Two types of in situ test can be carried out to characterize skid resistance: measurement of the macrotexture, and measurement of the longitudinal friction coefficient.

For the macrotexture, this is assessed by measuring the average texture depth according to standard NF EN 13 036-1. The on-site measurement should be taken as soon as possible after application and in any case within two weeks. The minimum acceptable values required by French standard are shown in table 10 below.

Table 10
Average texture depth values

Products	Minimum values observed on site (in mm)	Minimum values required by French standard (in mm)
ESU (MCO 2/4)	*No data*	0.6
ECF (0/6)	0.6	-
BBTM 0/6 type 1	0.6	0.7
BBTM 0/10 type 1	0.9	0.9
EB-BBMA 0/10	0.6	0.7
EB-BBMA 0/14	*No data*	0.7
EB-BBMB 0/10	*No data*	0.5
EB-BBMB 0/14	*No data*	0.7
EB-BBMC 0/10	*No data*	0.5
EB-BBA 0/10C	0.4	0.4 on airport ramp or apron and 0.6 on runways
EB-BBA 0/10 D	0.5	
EB-BBA 0/14 C	0.4	
EB-BBA 0/14 D	0.6	
EB-BBME 0/10	0.4	0.4
EB-BBME 0/14	0.4	0.5
EB-BBSG 0/10	*No data*	0.4
EB-BBSG 0/14	*No data*	0.5

Measurements of the longitudinal friction coefficient should be carried out on the surface courses of airport pavements as soon as the work has been accepted, and within 3 to 12 months of the commissioning of the pavement. They should be taken at two speeds: 65 km/h and 95 km/h. On acceptance of the work, the longitudinal friction coefficient values measured must be at least equal to those indicated in the decree on the technical characteristics certain land-based airports used by fixed-wing aircraft dated 10 July 2006.

When drawing up the technical clauses of the contract, the designer may suggest other values, as long as these are not less than those defined in Annex 1 of the decree.

In the case of measurements carried out within 3 to 12 months, the values to be achieved are those specified for new pavements. For example, in the case of measurements carried out with an IMAG (a French skid resistance measurement trailer), the following values are acceptable:

- 0.51 at a speed of 65 km/h
- 0.43 at a speed of 95 km/h.

CONCLUSION

France's standards for asphalt concrete materials are derived from European standards. They specify the requirements for mixtures from the same family of products used for surface courses and/or base courses of roads, airport pavements and other movement areas. The aim of this study is to help project managers to make better choices and to define more precisely in their contracts performance criteria for mixtures and the characteristics of their components, with a view to responding more pertinently to the requirements of each project. The most common types of requirement encountered in French metropolitan and overseas airports are covered. This study introduces a new concept called "aircraft group". This concept is more representative of the impact made by an aircraft on an airport pavement than simply its weight. It is arrived at by taking into consideration the aircraft's landing gear configuration and tyre pressures.

REFERENCES

1. ICAO Annex 14 to the Convention on International Civil Aviation : Aerodromes
2. Arrêté du 10 juillet 2006 relatif aux caractéristiques techniques de certains aérodromes terrestres utilisés par les aéronefs à voilure fixe, Annexe 1 : caractéristiques physiques, 2006.
3. LPC method no. 46 : Mesure de l'uni longitudinal des chaussées routières et aéronautiques, 2009.
4. Longitudinal profile analyser (http://media.lcpc.fr/ext/pdf/prod/mlpc/apl.pdf), 2008.